Capacitors Technology for Power Electronics

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Capacitors Technology for Power Electronics

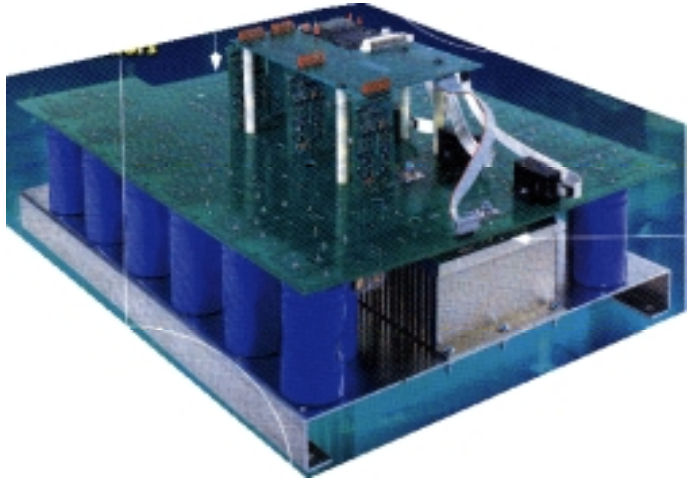
- Collaborators
  - M-J. Pan and W. Hackenberger, TRS Ceramics Inc.
  - Q. Zhang, R. Anklekar, S. Perini, and T. Shrout, PSU
- Sponsors
  - Office of Naval Research
  - Department of Energy, Office of Advanced Automotive Technology

Outline

- Capacitor technology for power electronics.
- Solid state capacitor development and characterization.
- Design considerations for capacitor arrays.

Capacitor Development for Power Electronics

- Reduce Capacitor Volume
  - reduce reliance on electrolytics
  - nonlinear dielectrics
- Integration and Packaging
  - volume savings
  - minimize **connectors**
  - decrease inductance
- Decrease Thermal Load
  - minimize switching losses
  - decrease capacitor series resistance (ESR)
- Reduce Cost
  - proportional to reduced volume
  - low cost electrode systems.



Volumetric Efficiency of Solid-State Capacitors

Capacitor Type (500 V)	Capacitance (μF)	Volume (cm^3)
Polypropylene	20	133
MLC (X7R)	22	16
MLC (AFE)/FE	20	(4*)

* Projection based on increasing dielectric constant from 1000 to 4000

High Energy Storage Capacitors

Needs:

Future Consumer Markets

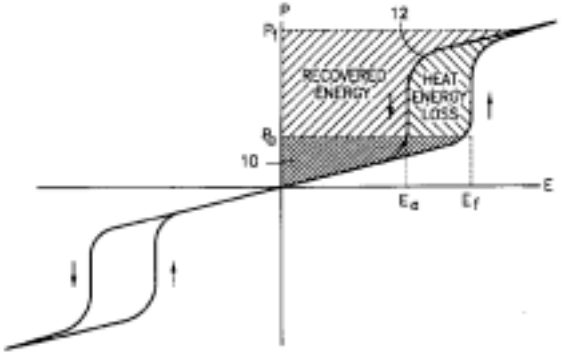
Electric Car — AC/DC converters
Trucks — Power switching
Medical — Cardiac defibrillators
Power Distribution/Utility Management

Niche Markets

Lasers
Camera flash units
Explosive detonators
Electric guns
High power lighting ignitors

CDS Research Thrusts:

* Antiferroelectric (phase switching) materials ~ 12J/cm^3
* High K polymers — irradiated PVDF K ~ 50, tanδ
* High K polymer composites
* Integrated varistor/capacitors
* DOE GATE (Graduate Automobile Technology Education) Program



U.S. Patent #5,728,138

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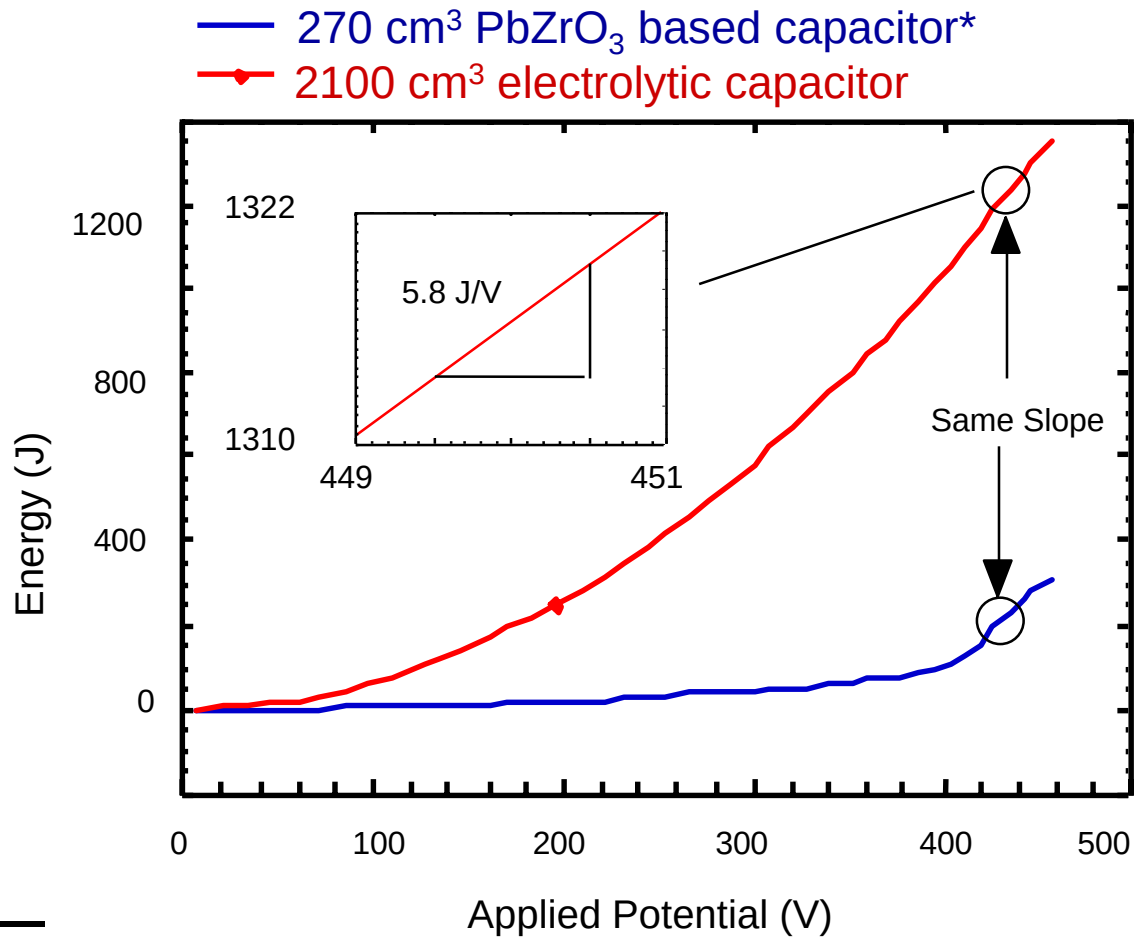
1 MW Inverter Capacitors

- Capacitor Energy Requirements
  - 450 V, 900 A, 10 µS
  - 4 Joules
- Electrolytic Capacitors
  - 13,800 µF,
  - 2100 cm^3 volume (includes package)
- Antiferroelectric/Ferroelectric Materials
  - 13,800 µF, 150 cm^3 volume
  - electrodes and packaging add extra volume

Conventional Electrolytic vs. Phase-Switching Capacitors



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Summary and Conclusions

- Materials Development
  - High-K polymers and AFE/FE.
  - Reliability and packaging.
- Components Development
  - 100 kW inverter test with ORNL.
  - Polymer and MLCC have lower ESR than electrolytic.
  - Determine a figure-of-merit.

Passive Components for Power Electronic Workshop

April 26-27, 2000 at Penn State

- For capacitor manufacturers, system designers, and circuit engineers.
- 20 international capacitor companies will attend.

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